

Science Update



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Mount St. Helens 30 Years Later: A Landscape Reconfigured

ON MAY 18, 1980, after two months of tremors, Mount St. Helens erupted spectacularly and profoundly changed a vast area surrounding the volcano. The north slope of the mountain catastrophically failed, forming the largest landslide witnessed in modern times. The largest lobe of this debris avalanche raced 14 miles down the Toutle River valley, filling it to an average depth of 150 feet. The landslide unleashed hurricane-force winds of hot gases filled with rocks that toppled 143 square miles of trees. Farther away, 42 square miles of trees were killed by the heat of the blast but left standing—ghostly sentinels still watching 30 years later.

Tephra (pumice) and ash ejected into the air during the eruption was deposited downwind. Areas close to the volcano received 2 to 3 feet of coarse pumice, while areas several hundred miles away were coated with a thin

The physical force of this event captivated worldwide attention. The lasting drama, however, has not been one of destruction but of reassembly.

layer of ash. Pyroclastic flows of hot (up to 1,560 °F) pumice and ash accumulated in deposits up to 130 feet thick. Mudflows triggered by melted snow and ice moved rapidly, overtaking obstacles in their path and in some cases traveling many miles downstream. After the eruption, the mountain once known for its conical symmetry had a gaping crater. The series of volcanic events left a unique imprint on the landscape, creating a mosaic of disturbance zones, ranging from areas where all life perished to zones with nearly complete survival.

The physical forces of this event captured attention worldwide. The lasting drama, however, has not been

one of destruction but of reassembly. Charlie Crisafulli, a research ecologist, and Fred Swanson, a research geologist, have led the research efforts of the USDA Forest Service, Pacific Northwest (PNW) (*continued on next page*)



The Mount St. Helens National Volcanic Monument in Washington was established by Congress in 1982 as a place for research, recreation, and education.

Tom Iraci

Key Findings

- Biological legacies, both living and dead, were important in development of the posteruption ecosystems.
- The timing of volcanic disturbances strongly affected biological responses at scales of time of day, season of the year, and stage of succession of the affected ecosystem.
- Ecological response to disturbance exhibited several distinct patterns at the broad scale (6 to 60 square miles) associated with (a) patches of surviving organisms, (b) hot spots for invasion, (c) encroachment from the perimeter of the disturbed area and other manifestations of dispersal limitations, and (d) cold spots created by extreme primary disturbance or subsequent chronic disturbance.
- Secondary disturbances such as small landslides and lateral shifting of river channels created a complex landscape mosaic in the decades after initial disturbance.
- Forest response to ashfall ranged from tree death to growth suppression of surviving trees to growth enhancement, depending on tree age and species, properties of the ash (e.g., depth, particle size distribution), and other factors.
- Hydrologic systems within volcanically disturbed landscapes have substantially altered streamflows and sediment loads that strongly influence stream and riparian habitat.
- Large, slowly regenerating landscapes can have extremely high levels of habitat diversity that support many early seral habitat specialists and regionally unique biological communities.



(from page 1) Research Station to study these processes over 30 years. They've been joined by dozens of scientists from universities and other research organizations across the country, documenting ecosystem reassembly.

Ten days after the 1980 eruption, Swanson and colleagues toured the blast area by helicopter. "It was stunning," recalls Swanson. "And it was possible to make some interesting observations right off the bat, things whose significance I didn't realize until some time later. We found what looked like spider webs in the tephra. I later learned these were mycelia of fungi—spores of fungal species that had evolved to respond to heat of a forest fire, but heat from the eruption had triggered them."

"Some time later" is a key phrase. Repeated observations over three decades have shifted views on ecosystem reassembly after a large disturbance. These efforts have yielded significant findings that have reshaped the thinking about the ecology of disturbed landscapes and managing these areas after disturbance.

Many of the assumptions about what would happen if we didn't do something after the eruption were wrong, explains Crisafulli. Concerns about fire and insect outbreaks in the thousands of acres of dead trees, for example, had some people calling for rapid salvage logging. An extensive salvage logging program was carried out on some blast area lands, but not within the 110,000-acre Mount St. Helens National Volcanic Monument established by Congress in 1982. Economically, the salvage logging helped recoup otherwise lost timber revenue, but ecologically, it led to a very different forest community than the one inside the monument. Scientists have since learned that the volcanic ash that coated the fallen trees reduced flammability and served as an effective insecticide.

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On May 18, 1980, the vertical eruption plume from Mount St. Helens continued for 9 hours. Ash rose 15 miles into the air and eventually encircled the globe. Photo by U.S. Geological Survey.

Erosion concerns led to aerial seeding using non-native species over part of the disturbed landscape. The limited success of this effort, and the success of natural revegetation, was instrumental in shifting the policy of land management agencies to use native seeds in erosion control efforts. It also highlighted the importance of critically evaluating site characteristics. “We learned that the substrate needs a certain amount of stability before seeding can be used as a tool to aid slope stabilization,” explains Crisafulli. “On Mount St. Helens, many hillside surfaces were not stable, and as a result, seeds sown onto unstable slopes were eroded along with the new surface layer of ash and tephra downslope.

These species have persisted in valley bottoms and the debris avalanche deposits, and are the source of some of the nonnative exotic plant communities today.”

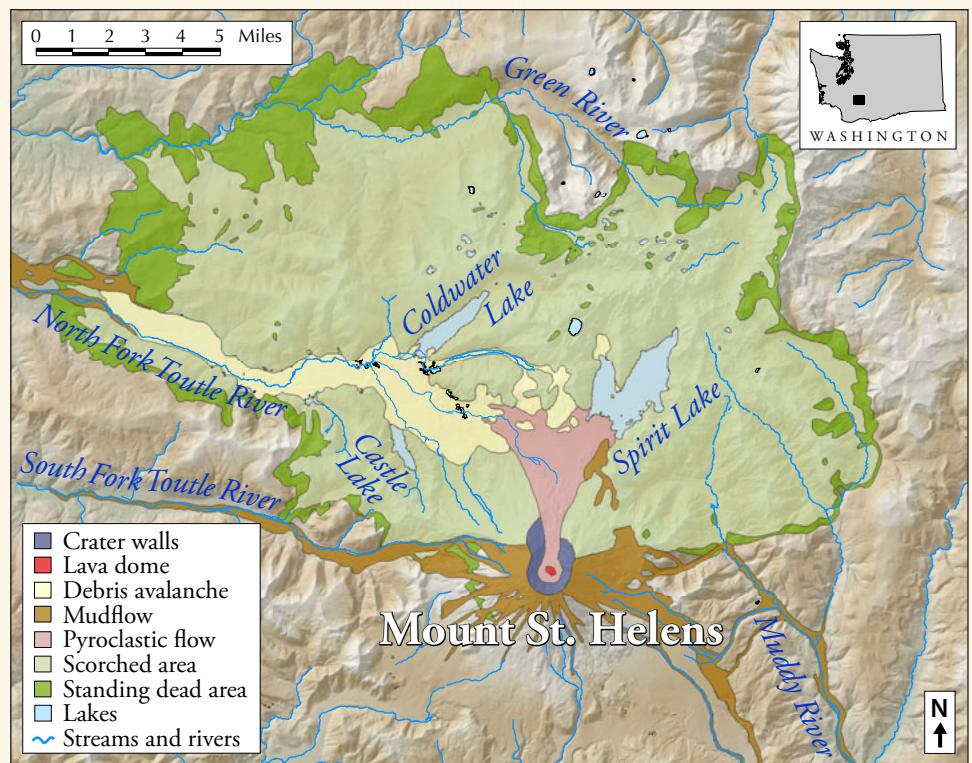
Even the process of natural revegetation yielded surprises. At the time, it was thought that plants and animals from the edges of the less disturbed areas would repopulate the altered landscape. “This did occur, but an unexpected amount of recolonization was done by species that managed to survive the blast in many widely distributed oases,” says Crisafulli. Over time, these protected oases coalesced, creating larger patches of survivors and their progeny, resulting in a complex mosaic of plant and animal communities.

Human activities have had a marked effect on vegetation development after the eruption. Most private, state, and national forest lands outside the monument, for example, were replanted within 5 years. Plantations of Douglas-fir and noble fir grew thickly and are now shading out many potential understory plants. In the monument, which for the most part, has been left to respond naturally to the disturbances, the forest is still in the early stages of succession. Red alder is the dominant tree on the debris avalanche deposit. In the blowdown zone,

An unexpected amount of recolonization was done by species that managed to survive the blast.

surprising combinations of species are found. Understory herbs, shrubs, and saplings of shade-tolerant trees from the previous old-growth forest survived the blast in numerous scattered patches under a protective cover of snow. Now 15 to 25 feet tall, late-successional species such as Pacific silver fir and mountain hemlock, and shorter stature big huckleberry and vine maple grow intermixed with sun-loving early colonizers such as fireweed and pearly everlasting. These observations have furthered understanding about succession—the process of ecological change. It is no longer seen as a single linear progression with one endpoint. Biological legacies from the pre-eruption forest defined the starting point for the new forest and will influence its development until interrupted by another disturbance.

These ecological lessons are the product of coordinated long-term research supported by the PNW Research Station, U.S. Geological Survey, universities, and National Science Foundation. Established as a site for research, recreation, and education, the Mount St. Helens National Volcanic Monument has served as a living laboratory where each field season yields new information. *



The volcanic events, including debris avalanches and mudflows, created a mosaic of disturbance over 380 square miles in the Cascade Range of southern Washington.

Theresa Valentine and Keith Rourtman



Tom Iraci

A surviving fern pushes through the tephra.

Cascading Phenomena

SPRING COMES LATE to the subalpine forests of Washington's Cascade Range. On the morning of May 18, 1980, patches of snow lingered on the upper flanks of Mount St. Helens. In shady, protected sites the snow sheltered small animals, shrubs, young trees, and all the fungi and soil micro-organisms living beneath them. Many of the lakes were still ice bound, shielding fish and other aquatic life from the upper world. The migratory songbirds had yet to arrive, and most of the salmon runs that spawn in the region's streams were still at sea. With the breaking of dawn, the nocturnal wildlife such as deer mice and voles had retreated to their underground dens.

Then the volcano erupted, and rather than simply setting the scene, these details about timing and season would come to have a lasting effect on the trajectory of the landscape's reassembly. "The role of chance and the influence of survivors on succession can't be overstated," says Charlie Crisafulli. "Had the eruption happened at another time of day or season, the ecological consequences would have been markedly different."

The eruption reset ecological systems, dramatically "rebooting" parts of the blast area. But even within the blast area, there were survivors. Smaller organisms were favored, and even smaller individuals within a species. Mice survived, elk didn't. Large overstory trees perished, whereas smaller saplings of the same species lived. In the broad arc extending 17 miles north of the volcano, the forest overstory was killed, but isolated individuals or patches of organisms survived in numerous locations.

"The diversity of surviving organisms and the means by which they survived were striking," recalls Crisafulli. "For example, a log carried downstream in the mudflow

instantly transported nutrients, microbes, fungi, and even small animals to a 'new' system devoid of organisms." Such phenomena created islands of life in otherwise inhospitable habitat. Whole plants regenerated from root fragments that were carried downstream and deposited along river margins.

These remnants of the old landscape came to be known as "biological legacies," and their influence on the new landscape was significant. This concept has since been incorporated into forest management through harvest practices that retain individuals and patches of live and dead trees to serve as refuges and source populations for species that then recolonize the adjacent disturbed area.

Patterns of response

"Lake, stream, and terrestrial systems were strikingly different in their rates of ecological responses following the 1980 eruption," explains Crisafulli. In general, aquatic systems rebounded much faster than terrestrial systems, and among aquatic systems, lakes responded more quickly than streams and rivers.

Most lakes in the blast area had a rapid reduction in productivity, caused by volcanic and forest debris that reduced light penetration into the water. This was followed by a spike in productivity as the debris settled and organisms responded to the influx of nutrients. Within a few years, water quality in most lakes had returned to levels similar to those of undisturbed lakes in the Washington Cascade Range. However, some measures of water chemistry remained elevated for decades.

Spirit Lake, the lake closest to the volcano and the most severely impacted, has provided unparalleled research opportunities. "Never before have scientists been able to study a nearly pristine lake with cold, crystal-clear water instantly transformed to nearly black, tepid, fetid water, choked with logs and forest debris where only bacteria could live, and then track a series of fascinating and unprecedented changes that would occur over the next three decades," says Crisafulli.

For 30 years, scientists have monitored Spirit Lake, documenting increase in light transmission, return of oxygen, changes in nutrient levels, demise of vigorous microbial communities, and the colonization of hundreds of plant and animal species. The lake had been fishless since the eruption until 1993 when rainbow trout were found, presumably stocked illegally. Since then, the rainbow trout population has expanded rapidly, but exhibits unusual life histories. They grow fast and large, have unusual spawning characteristics, and die young, compared to trout in

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most mountain lakes. The rapid growth of the trout is most likely related to the highly productive near-shore aquatic vegetation that supports enormous populations of mayflies, midges, and snails—the primary prey of these fish. Currently, research is focused on determining the factors responsible for several of the other unusual characteristics of Spirit Lake trout.

The debris avalanche that flowed down the north fork of the Toutle River dammed tributary streams, leading to the formation of two new lakes and about 150 ponds. Many of these ponds formed in low spots, among the hummocks of rocky debris, and were filled by rain and groundwater. In another unique research opportunity, scientists documented colonization of newly created pond habitats by amphibians after a large disturbance.

"One year after eruption, the Pacific tree frog and western toad had arrived and begun colonizing these ponds," says Crisafulli. "The nearest known populations were several miles away across a really barren area. We didn't know if they'd survive. Some of the ponds had warm water. Would there be food?" The frogs and toads did survive and began reproducing that year. Nine years later the first salamander appeared. In total, six of the seven potential pond-breeding amphibians in the southern Washington Cascade Range had colonized and established breeding populations in these newly created ponds.

The terrestrial communities in the blast area still have not reached the same levels of productivity that they had before the eruption; that is expected to take decades. Before the 1980 eruption, the forest was typical of the west side of Washington's Cascade Range, dominated by Douglas-fir, western and mountain hemlock, and Pacific silver fir in the overstory, with numerous species of moss, lichens, herbs, and shrubs in the understory. It will likely take centuries for forest structure and plant and animal communities that resemble the pre-eruption forest to develop within the blast area.

Charlie Crisafulli



During the 1980 eruption, Spirit Lake was dramatically transformed from a deep, cold subalpine lake to a shallow, warm broth habitable only to anaerobic bacteria. Since then, scientists have tracked the processes that have made it habitable once again to hundreds of plant and animal species, including fish. The floating log mat, a remnant of the pre-eruption forest that grew on the slope above the lake, persists 30 years later.



A scientist collects information on the plant communities in Spirit Lake, where waterfowl likely played a key role in reintroducing vegetation to the lake. Photo by Interspot of Vienna.



It is expected to take decades for terrestrial systems to reach pre-eruption productivity. In contrast to the forest that was there before, the Pumice Plain is relatively barren. Photo by Charlie Crisafulli.



Succession of disturbance processes

Subsequent disturbances have highlighted the connections between ecological and geological processes. This is particularly evident in the debris avalanche and mudflow deposits along the north fork and main stem of the Toutle River. “Floods are really important in sculpting the landscape,” says Swanson. “We’ve had several big ones since the eruption, and they have triggered many landslides and altered river channels. The profound landscape change by the initial disturbance combined with slow development of forest cover sets the stage for frequent secondary disturbance triggered by unusually intense rain, or extreme rain-on-snow events.”

Secondary disturbances such as surface erosion, landslides, and floods have helped define “hot” and “cold” spots of ecological recovery. Many riparian areas have been ecological hot spots because they had a relatively high rate of surviving species adapted to flood disturbance, and ready sources of water and nutrients. In some places, erosion also led to hot spots where shallow gullies stripped the nutrient-poor tephra deposits, exposing the nutrient-rich pre-eruption soil, and facilitated sprouting from buried

plant parts. However, in other sites, repeated disturbance from landslides and other erosion processes has continually reset the successional clock, leading to cold spots hospitable to little or no life. Secondary disturbances have clearly created a complex mosaic of vegetation with diverse successional pathways.

Ecological succession

Succession is the process of directional change in the structure and composition of ecosystems following disturbance. As researchers on Mount St. Helens have observed, succession does not follow

Succession does not follow an orderly path to a single endpoint. It has different starting points, stages, and interruptions by subsequent disturbances.

an orderly path to a single endpoint. It has different starting points, stages with different mixes of species and dominance patterns, and interruptions of successional trajectories by subsequent disturbances or other factors.

Wind played a key role initiating early-succession processes by blowing in spiders, insects, and seeds from the

perimeters of the disturbed areas and transporting these organisms from surviving patches within the disturbed area. Prairie lupine, the purple-blue wildflower with soft silvery-green palmate leaves, was first observed growing on the otherwise barren Pumice Plain in 1982. The first seeds likely arrived by wind from surviving individuals high on the volcano’s slopes. Each lupine plant created a microhabitat that was hospitable to several other plant species. Like other legumes, lupine chemically improves the soil for other vegetative species by “fixing” atmospheric nitrogen. The plants also physically trap windblown debris and attract insects, many of which ultimately die on or around the plant. As these bits of organic matter decompose, they also enrich the soil. Researchers found that soils under lupines have much higher total nitrogen, organic material, and microbial activity than adjacent bare areas.

Ecological succession on the Pumice Plain has been further influenced by the interactions among lupine, northern pocket gopher, and elk. In many nearby areas, gophers survived the blast in underground refuges. Where new volcanic debris wasn’t too deep, gophers tunneled through it, mixing the old



Researchers count and measure western toad tadpoles in Spirit Lake.
Photo by Charlie Crisafulli.



A researcher measures habitat characteristics at a bird monitoring study site.
Photo by Charlie Crisafulli.

soil with the new deposits, creating an ideal growth medium for new seedlings. These tunnels also served as subterranean highways for amphibians, such as salamanders, providing a damp refuge away from the heat of the treeless areas. As elk moved back into the area, foraging on Indian paintbrush, they broke through the tephra crust, further mixing the soils. Elk droppings deposited in the blast area contained seeds, fungal spores, and other organic material from adjacent areas that influenced the development of new vegetation patches. Crisafulli demonstrated this by bringing elk feces from the Pumice Plain back to the laboratory greenhouse where six species of plants and several fungi species germinated from the samples. Within a few years, the lupine patches on the Pumice Plain became biological hotspots facilitating the colonization of other plant species and attracting numerous insects, birds, and small mammals, in what had been a barren landscape.

Early colonizers: Native or nonnative?

“The eruption left a denuded landscape and created vast open terrain,” says Crisafulli. “Community ecology theory predicts that large open areas with

reduced species diversity and low abundance following disturbance should be susceptible to invasive species. Following disturbance, resources become available, and competitors, predators, and parasites are frequently few. Many exotic invasive species are strong dispersers, and once arriving to a recently disturbed site may establish and spread to a point where they influence the ability of native species to colonize and alter soil chemistry. Based on this thinking, we predicted that Mount St. Helens would potentially be susceptible to exotic invasive species, particularly wind-dispersed herbs.”

Lupine patches on the Pumice Plain became biological hotspots on what had been a barren landscape.

“Thirty years later, while numerous nonnative species have colonized alongside native species, and in some cases have attained locally high coverage, there are no examples of exotic species dominating large areas of the disturbed landscape or waterways,” Crisafulli continues. “Many of the earlier colonizing species have included nonnative, sun-loving herbs such as bent grass, Canada thistle, groundsel, and cats-ear. For

the most part, we have seen these species wane in abundance over time. The abundance and area covered by exotic plant species is related to elevation with fewer exotics in high sites. In lower elevations of the Toutle and Muddy River Valleys, exotic herbaceous species like lotus and clover are very abundant, and woody species like Scotch broom spread to a point where management agencies have employed manual and chemical control. It is unclear if Scotch broom would have dominated these sites in the absence of active control. As red alder trees expand their coverage, they alter the light regime and create unfavorable conditions for exotic species that have colonized thus far. Therefore, these exotic species likely pose few long-term problems for native species, but likely have had some influence on early successional processes,” explains Crisafulli.

Very few colonizing animals have been nonnative. One, however, the willow stem-boring beetle, is influencing succession. Crisafulli first documented the beetle in 1989. Over the next 15 years, he observed that in heavily disturbed sites where willow colonized, a suite of birds and small mammals would also colonize. Then the beetle would appear and lay eggs on willows



Lupine and pocket gopher have influenced the development of plant and animal communities in the blast area. The presence of lupine (on the Pumice Plain) and gopher (in the blow-down forest) facilitated colonization by other species. All photos above by Charlie Crisafulli.

The willow stem-boring beetle annually kills a large percentage of willows on the Pumice Plain and is thus influencing development of other plant and animal communities.

stems. When the larvae hatched, they bored into the stem, weakening or killing it. “It became ecological musical chairs,” says Crisafulli. “The willows grew, attracting birds and mammals; then the beetle set the process back. Then the beetle population shrank as it used up its food source.” Once the beetle had exploited most of the willow stems in a particular patch, it moved onto the next suitable patch and reinitiated the process. The willow in the exploited patch rebounded until the shoot attained a certain size and became susceptible once more to the beetle. As observed on the Pumice Plain, the net effect appears to be a chronic reset in the developing woody plant cover and the animal communities and microhabitats associated with them.

Crisafulli shared these observations with colleagues at the 2005 science pulse—a gathering by researchers to discuss recent scientific findings about the ecology of Mount St. Helens. It seemed the beetle was broadly affecting patterns of ecological succession across the Pumice Plain. Crisafulli and his colleagues applied for and received a grant from the National Science Foundation in 2006, and now several projects focus on the willow stem-boring beetle and its direct and indirect influence on Mount St. Helens ecology.

Looking forward

Mount St. Helens remains an active volcano. A new lava dome formed in the crater between 2004 and 2008, and a new glacier is growing in the crater—one of the few in the world that’s not shrinking. Erosion of avalanche deposits continues to send vast quantities of sediment downstream, creating problems for municipalities and property owners in the valley below. “The timescale of the geological phenomena is overlapping with ecological change,” says Swanson. Based on the past

The timescale of geological phenomena is overlapping with ecological change.

eruptive history, the next eruption is likely to occur within the lifespan of trees now establishing on sites wiped clean by the 1980 eruption.

Changes in climate may lead to changes in storm patterns and intensity, and the timing and type of precipitation. Warming is likely to alter snow accumulation and melt rate, possibly influencing flooding and water availability, which may strongly influence succession. Wolves are expected to enter the St. Helens area within 5 to 10 years, migrating from British Columbia, Oregon, Idaho, or eastern Washington. The

direct and indirect influences wolves have on food webs are well documented in other areas of the Western United States, and similar or more pronounced influences could be expected at Mount St. Helens.

Summer 2010, researchers will convene on Mount St. Helens, for the fifth science pulse since the 1980 eruption, to continue long-term observations and discuss the next

research questions. From Crisafulli’s view, the next step is to “scale up observations from the plot level to broader scale using landscape perspectives, remote sensing, and GIS approaches.” Remote sensing data combined with plot measurements from the past 30 years would allow researchers to begin modeling landscape reassembly and develop and test predictive models based on plot-level work.



Charlie Crisafulli

Pacific tree frogs began colonizing newly formed ponds 1 year after the eruption.

It’s not possible to measure every site, explains Crisafulli. A model with outcomes that can be validated by plot data enables researchers to extrapolate findings across a broader landscape. This would improve understanding of ecosystem processes occurring at multiple spatial scales on Mount St. Helens, and the approach could be applied to other disturbed landscapes. ☀

The Role of Science in Managing Mount St. Helens

MOUNT ST. HELENS National Volcanic Monument lies within the Mount St. Helens Ranger District of the Gifford Pinchot National Forest. While the monument is managed for research, recreation, and education, according to its congressional mandate, the other 75 percent of the district is managed like any other national forest land—providing for timber, mining, recreation, and other uses. The presence of an active volcano and associated research area within the national forest, however, influences activities outside the monument.

“Having the monument in our district changes the way we interact with the public and our other constituents,” says monument manager and district ranger Tom Mulder. “An active volcano on the district changes our perception of disturbance. Timber sales, road building, bridges—these are things that are typically seen as big disturbances.” But when considered in the context of landscape shaped by volcanic eruptions, disturbance becomes “an interesting philosophical discussion.”

The eruption and subsequent changes in the landscape shifted the management paradigm, Mulder explains. “Disturbance is part of the natural process. Change is constant on the landscape. What we want to see are ecosystems that are resilient.”

Before the 1980 eruption, Mount St. Helens was a recreation destination in southwest Washington. Although areas have been reopened to hiking, camping, boating, fishing, and hunting, other areas remain off limits to certain recreation activities. “Some people say, ‘you’re doing science at the expense of the recreation. After 29 years, haven’t you learned enough?’” says Mulder. “I explain that we’re doing science on a changing landscape, looking at processes that take hundreds, thousands, and even millions of years. These are very long cycles, not a fiscal year, not a gardening season. Thirty years is a very short time, not even a blink of an eye in geologic time.”

Science and recreation don’t have to compete, contends Mulder. “Part of our passion here is science as recreation. We can transfer knowledge through recreational activities,” he says. “Climbing to the rim of a volcano—you’ll remember that for a lifetime. Learning about some of the process at work from a climbing steward—that’s a tremendous learning opportunity. If you take a course in a classroom, you remember one-tenth of the material; a year later, you might remember a tenth of that tenth. But spend time outside and

Disturbance is part of the natural process. Change is constant on the landscape. What we want to see are ecosystems that are resilient.



Charlie Crisafulli

SCUBA crews surveyed plant communities and vegetative biomass in Spirit Lake.

you’ll remember so much more because of the grandeur of the landscape,” says Mulder.

Peter Frenzen, the monument scientist, agrees. “There is tremendous value added to a guided hike or field trip when accompanied by a scientist, ranger, or trained volunteer. It gives participants a greater appreciation for what’s happening here. Field science doesn’t usually touch the lives of most people. Here, they get to meet scientists and get hooked into their enthusiasm.”

“Tourism with an education component is growing,” says Frenzen. “People want to have meaningful outdoor experiences. This is accompanied by an aging, well-educated population that is looking for meaningful things to do. These are also the type of people who make good volunteers.”

Because of budget cuts, the Gifford Pinchot National Forest has come to rely more on volunteers in recent years. The forest partners with the Mount St. Helens Institute, a private nonprofit organization that helps people connect

with Mount St. Helens through education, research, and stewardship. Researchers like Charlie Crisafulli, and counterparts with the U.S. Geological Survey, educate volunteers through the institute who then serve as interpretive volunteers at the visitor centers or climbing stewards on guided climbs. “This is a tremendous draw for the volunteers,” says Mulder. “They get firsthand explanations of immediate findings with premier scientists.”

These findings are passed on directly through interpretive programming for visitors. In 2009, of the 200,000 visitors to Johnston Ridge Observatory, 78,000 attended an interpretive program or had informal interpretive contact with a ranger or volunteer. *



Charlie Crisafulli

A field trip to the Pumice Plain during the 2005 Science Pulse.

The Path of Discovery

MOUNT ST. HELENS is the most studied volcano in the world, and the value of the research is enhanced by the effort to conduct it in a coordinated manner. This doesn't happen by accident; it takes the support of research agencies, universities, the public, coordinated logistics, and long-term vision. The lessons learned on Mount St. Helens, both the scientific findings and the ways of managing long-term research, are now being applied around the world.

Peter Frenzen, the monument scientist with the Gifford Pinchot National Forest, handles much of the permitting and logistics. "We want to make sure prospective researchers have good information so that one plot doesn't end up on top of another, or a soil sampling pit doesn't end up in someone else's vegetation plot," he explains.

"Another part of my job is connecting people, putting researchers new to the area in touch with a researcher already working there. The choice of what to measure can be informed by the insights of someone who is already working there," says Frenzen. He'll provide a graduate student with an orphaned data set, for example, which has the dual benefit of extending the data set and enables the student to do a more detailed analysis than would be possible based on just one or two years of data. "We're trying to pass the baton from one generation of researchers and data plots on to the next," Frenzen says.

Science pulses

Four times since 1980, a cadre of scientists from around the country has convened at Mount St. Helens. According to Fred Swanson, these "science pulses" have been instrumental in maintaining the momentum necessary for conducting research that spans decades.

"With the leadership of Jerry Franklin, we organized the first pulses in the summers of 1980 and 1981 to help as many ecologists get into the area as possible," recalls Swanson. "Access to Mount St. Helens then was very limited. We needed helicopters, and 4-wheel-drive vehicles, radios and passes to get through all the gates." About 160 researchers and media participated during the 2-week event. "We'd go out in the field during the day and share what we were observing during the evenings. It really helped build communication and camaraderie across the scientific community involved there. And, I think it helped lay some of the groundwork for collaborations that continue today," says Swanson.

Subsequent science pulses were held in 2000 and 2005, and one is planned for 2010. Now the focus is to have researchers resample study sites, develop new collaborations, bring new scientists to fill behind those who will soon retire, and start new lines of inquiry.

Data archiving

"Our long-range intent is to have all of the primary long-term data sets well documented and posted online. This is the kind of information management system the National Science Foundation [NSF] expects of research sites of this caliber. If we can provide this infrastructure for Mount St. Helens researchers competing for NSF grants, those researchers have an advantage in securing funding," says Swanson.

Other types of documentation, such as Web sites with photo libraries and film documentaries, are important for maintaining the public's interest in Mount St. Helens research. From a human perspective, "30 years is a long time," says Frenzen, "but people can relate, particularly because we have records and pictures of the change. It makes the process more understandable. You get a sense of how dynamic the landscape is."

"Young people may set the course of their professional lives based on a visit or images of the site they see in a *National Geographic*, depending on how their imagination is stimulated," says Swanson. "The more ways we can expose people to the beauty of the landscape and the processes at play, the better."

International application

In March 2009, at the request of Chilean academics and government officials, Crisafulli and Swanson traveled to Chile where Chaitén Volcano had recently erupted 10 months before. "We wanted to test some of the lessons of Mount St. Helens in another volcanic setting," said Swanson. The two sites share some similar characteristics, including temperate rain forest dominated by long-lived



Chaiten Volcano, Chile, erupted in May 2008, providing opportunities to test lessons learned from Mount St. Helens in another volcanic setting.

Charlie Crisafulli

species, steep topography, and maritime climate. The two scientists made a second trip in January 2010 to continue their observations and to provide assistance in building capacity for long-term volcano ecology science.

In May 2008, Kasatochi Volcano, a tiny Aleutian island in the Bering Sea, erupted. At the request of the U.S. Geological Survey and U.S. Fish and Wildlife Service, Crisafulli headed north to Anchorage, Alaska, to lead a discussion on developing plans for long-term study of ecological response to volcano disturbance.

"Kasatochi provides a wonderful contrast to studying the Mount St. Helens and Chaiten Volcanoes located in a temperate and continental setting," says Crisafulli. "The conditions are much harsher. There's a very short growing season, it's surrounded by a cold ocean, and lacks a nearby mainland to provide source material for colonization."

Among the key points Crisafulli and Swanson shared with researchers and officials at both sites was the importance of establishing well-integrated, long-term, multi-disciplinary studies. They suggested a research design that includes study plots arrayed along disturbance gradients and different types of ecosystems, an information management system so data are available in perpetuity, and a research environment that fosters open sharing of ideas and information—an important feature of the Mount St. Helens experience. *

Science Update

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S U M M A R Y

The May 18, 1980, eruption of Mount St. Helens dramatically transformed forests, meadows, lakes, and streams within a vast portion of the Cascade Range in southern Washington. Within days, scientists were on the scene and have remained, documenting the process of ecosystem reassembly. The eruption created exemplary opportunities to learn how plants and animals initially respond to large, intense disturbance and the longer term process of succession. Findings from this work have advanced understanding of disturbance ecology and shifted thinking on how to manage landscapes after disturbance. For example, biological legacies—remnant woody structure and surviving organisms—were found to strongly influence the plant and animal communities that develop after the disturbance. This discovery contributed to changes in forest harvest policies, leading to the practice of leaving some live and dead trees within harvest areas. Key ecological lessons from Mount St. Helens and the process of doing long-term research have also yielded information that scientists with the Pacific Northwest Research Station are now sharing with others around the world.

For More Information

Dale, V.H.; Crisafulli, C.M.; Swanson, F.J. 2005. 25 years of ecological change at Mount St. Helens. *Science*. 308: 961–962.

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Goodrich, C.; Moore, K.D.; Swanson, F.J., eds. 2008. In the blast zone: catastrophe and renewal on Mount St. Helens. Corvallis, OR: Oregon State University Press. 128 p.

Cascades Volcanic Observatory Web page: <http://vulcan.wr.usgs.gov/>

Mount St. Helens Institute Web page: <http://www.mshinstitute.org/>

Mount St. Helens National Volcanic Monument Web page:
<http://www.fs.fed.us/gpnf/mshnvm/>

U.S. Forest Service, Pacific Northwest Research Station, Mount St. Helens Web page: <http://www.fs.fed.us/pnw/mtsthelens/>

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